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September 25, 2014

VIA E-MAIL (BLACK.CHRISTOPER@EPA.GOV)
VIA U.S. MAIL

Christopher Black
Project Manager
U.S. EPA, Region 5
77 W. Jackson Blvd. LU-9J
Chicago, IL 60604

Re: Submittal of the Risk Mitigation Plan for the Ferro Corporation Facility located at 7050 Krick Road, Walton Hills, Ohio 44146 Docket Number RCRA-05-2011-0018

Dear Mr. Black:

Ferro Corporation (Ferro) is submitting a copy of the *Risk Mitigation Plan* for the Ferro Corporation Facility located at 7050 Krick Road, Walton Hills, Ohio.

If you have any questions regarding the document being submitted herein, please feel free to contact me at 216-875-5781.

Sincerely,

Kelly Wolfe

Kelly Wolfe,
Corporate Manager, EHS Manager
Ferro Corporation

cc: John Evans, Ferro Corporation
Jason Perdion, Baker & Hostetler
Eric Wilburn, Hull & Associates, Inc.

RISK MITIGATION PLAN OF ENVIRONMENTAL MEDIA

FOR THE:
FERRO CORPORATION FACILITY
7050 KRICK ROAD
WALTON HILLS, OHIO 44146

PREPARED FOR:
FERRO CORPORATION AND
BAKER & HOSTETLER LLP
1900 EAST 9TH STREET
CLEVELAND, OH 44114

PREPARED BY:
HULL & ASSOCIATES, INC.
4 HEMISPHERE WAY
BEDFORD, OHIO 44136

SEPTEMBER 2014

HULL

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1.0 INTRODUCTION

Hull & Associates, Inc. (Hull), on behalf of Ferro Corporation (Ferro) has prepared a Risk Mitigation Plan (RMP) for the Ferro Corporation facility located at 7050 Krick Road in Walton Hills, Ohio (Site). The location of the Site is shown on Figure 1. Site features are shown on Figure 2.

1.1 Purpose of the Risk Mitigation Plan

The purpose of this RMP is to outline risk mitigation measures that apply to construction/excavation workers and contractors involved in intrusive activities at the Site who may come into contact with chemicals of concern (COCs) during excavation activities. Construction/excavation workers and contractors are anticipated to be involved in intrusive subsurface activities during construction or excavation activities at the Site and may come in contact with soil and/or groundwater at the Site as well as surface water and/or sediment within the unnamed tributary to Tinkers Creek located in the northwest portion of the Site; this plan is designed to protect those workers.

1.2 Implementing the Risk Mitigation Plan

The responsibility for implementing this RMP belongs to the owner(s) of the Site. Risk mitigation measures should be periodically reviewed by the owner(s) to assure their effectiveness and should be revised, as needed, based on any additional subsurface investigation results and/or the implementation of any remedial activities. The risk mitigation measures described herein are to be implemented at two distinct areas of the Site in order to protect construction/excavation workers and contractors that may be involved in intrusive activities at the facility. These two distinct areas are depicted on Figure 3; the potential health risks identified in these areas are discussed in Section 2.0.

2.0 POTENTIAL HEALTH RISKS

A single concentration of arsenic exceeding its respective background concentration was identified in soil samples collected at the Site during recent environmental investigations. This single concentration also exceeds applicable hazard and/or risk goals. In addition, concentrations of trichloroethene in groundwater at select groundwater monitoring well locations exceed applicable risk goals. These exceedances present a potential health risk for a construction worker. Exposure to these COCs (and others) at the Site may occur through breathing, direct skin contact, and inadvertent ingestion with soil and/or groundwater during intrusive activities.

An unnamed tributary to Tinkers Creek is located in the northwest portion of the Site. Sediment and surface water from the unnamed tributary were determined not to exceed applicable hazard and/or risk goals for construction/excavation workers. However, construction/excavation workers may be exposed to any combination of soil, groundwater, sediment and/or surface water during intrusive activities at the Site. Therefore, although there are no specific COCs in sediment or surface water that exceed applicable hazard and/or risk goals, personal protective measures directly related to sediment and surface water exposures are discussed further in Section 3 of this RMP.

2.1 Current Potential Health Risks at the Site

Potential safety and health hazards to persons working at the facility have been identified. The key to risk mitigation is an ability to recognize situations that may produce hazardous conditions and to plan to mitigate those conditions before illnesses and/or injuries can occur. Exposures to concentrations of arsenic in soil in the southwestern portion of the Site, immediately adjacent to the Polyamine Building as well as trichloroethene in groundwater in the west-northwest portion of the Site are of primary concern to construction/excavation workers and contractors involved in intrusive activities at the Site. Refer to Figure 3 for generalized locations of arsenic in soil and trichloroethene in groundwater at the Site. It should be noted that the concentration and presence of trichloroethene observed in groundwater from monitoring well HMW3 is likely attributed to the presence of tetrachloroethene in groundwater from the same location. Although tetrachloroethene was not found in Site-wide groundwater at a concentration that exceeded applicable risk goals, daughter products resulting from the breakdown of tetrachloroethene including cis-1,2-dichloroethene, vinyl chloride, and as identified herein trichloroethene were observed in groundwater from monitoring well HMW3. Therefore, a brief summary of arsenic and trichloroethene, which are the subject of this RMP and their associated health risks is included below. In addition, health risks associated with exposure to cis-1,2-dichloroethene, tetrachloroethene, and vinyl chloride have also been summarized herein for informational purposes only.

Note that exposures to arsenic and the chlorinated compounds referenced herein only refer to direct contact exposures (*i.e.*, incidental ingestion, dermal contact, inhalation of particulate emissions from soil to outdoor air, and inhalation of volatile emissions to outdoor air) to the environmental media identified herein (*i.e.*, soil and groundwater) by on-Site construction/excavation workers during intrusive activities at the Site. Further evaluation of additional receptor populations and complete exposure pathways not addressed herein can be found in the *Summary and Assessment of Baseline and Delineation Investigation Activities* report (Hull, 2013).

2.2 Arsenic

Arsenic is a naturally occurring element widely distributed in the earth's crust. Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching.

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs. Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs.

Please refer to Appendix A for the Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs™ and Public Health Statement for arsenic, which contains more detailed relevant information in nontechnical language.

2.3 Trichloroethene

TCE is a colorless, sweet smelling liquid and used as a solvent for cleaning metal parts. It is has also been used as an ingredient in adhesives, paint remover, typewriter correction fluid and as a spot remover in the dry cleaning industry. TCE is not thought to be naturally occurring, but is commonly found in the groundwater as a result of chemical manufacturing, use and disposal. Drinking or breathing high levels of TCE can cause nervous system effects, liver and lung damage, abnormal heartbeat, coma and possibly death. TCE is reasonably anticipated to be a human carcinogen.

A copy of the ATSDR ToxFAQs™ for TCE is included in Appendix A.

2.4 cis-1,2-Dichloroethene, Tetrachloroethene, and Vinyl Chloride

The chemical cis-1,2-dichloroethene is an highly flammable, colorless liquid with a sharp, harsh odor. It has historically been used as a solvent for waxes and resins and as a degreasing agent. This chemical is found in groundwater due to anaerobic degradation of highly chlorinated compounds such as tetrachloroethene and trichloroethene.

Humans can be exposed to cis-1,2-dichloroethene through breathing, or drinking contaminated tap water. Breathing high levels of cis-1,2-dichloroethene can make you feel nauseous, drowsy and tired. Breathing extremely high levels can cause death. Drinking high levels of cis-1,2-dichloroethene can cause liver damage and a decreased number of red blood cells. There is currently inadequate evidence to classify cis-1,2-dichloroethene as a human carcinogen.

Tetrachloroethene is a manufactured chemical that is widely used for dry cleaning of fabrics and for metal-degreasing. It is also used to make other chemicals and is used in consumer products. Tetrachloroethene has a sharp, sweet odor and is a nonflammable liquid at room temperature.

Exposure to tetrachloroethene at high concentrations can cause dizziness, headache, sleepiness, confusion, nausea, difficulty speaking and walking, unconsciousness and death. The health effects of breathing in air or drinking water with low levels of tetrachloroethene are unknown. In studies with animals, higher doses show that tetrachloroethene can cause liver and kidney damage. Additionally, tetrachloroethene is reasonably anticipated to be a human carginogen.

Vinyl chloride is a colorless gas that burns easily and is not stable at high temperatures. It is a degradation product of tetrachloroethene and trichloroethene and is commonly found in conjunction with those two compounds. Vinyl chloride is used to make a variety of plastic products, including pipes, wire, cable coatings and packaging material.

Breathing high levels of vinyl chloride for short periods of time can cause dizziness, sleepiness and unconsciousness. Breathing vinyl chloride for long periods of time can result in permanent liver damage, immune reactions and liver cancer. Exposures to extremely high concentrations of vinyl chloride can cause death. Other routes of exposure include drinking water from a contaminated well. Vinyl chloride is a known human carcinogen. Breathing vinyl chloride over many years showed an increased risk of liver, brain and lung cancer.

A copy of the ATSDR ToxFAQs™ for cis-1,2-dichloroethene, tetrachloroethene, and vinyl chloride is included in Appendix A.

3.0 RISK MITIGATION MEASURES FOR CONSTRUCTION/EXCAVATION WORKERS

Construction/excavation activities associated with facility maintenance and/or expansion are reasonably anticipated to occur at the Site. This section details additional risk mitigation measures to be utilized on the Site to protect construction/excavation workers and contractors from exposures to COCs,primarily arsenic in soil and trichloroethene in groundwater, as well as exposures to sediment and surface water at the Site.

It is anticipated that contracted construction/excavation workers will provide a project-specific health and safety plan (HASP). All contractors will be expected to adhere to the safety practices for their respective specialties and Site-specific HASP(s). Contractors should also be notified about the risks posed to them by the COCs in soil and groundwater at the Site (primarily arsenic and trichloroethene, respectively). Each contractor and worker will also need to review this RMP and sign the worker acknowledgement form located in Appendix B of this document.

3.1 Precautions Against Exposures to Contaminated Media

Exposures to arsenic in soil on the Site could occur when construction/excavation workers come in direct contact with soil near the Polyamine Building; and, exposures to trichloroethene in groundwater on the Site could occur when construction/excavation workers come in direct contact with groundwater in the west-northwest portion of the Site. In addition, although not anticipated, construction/excavation workers may also come into contact with sediment and surface water within the unnamed tributary to Tinkers Creek. Contact can include dermal contact with exposed skin, such as bare hands and forearms, incidental or inadvertent ingestion when soil gets on food, such as transfer from dirty hands to food or tobacco, or breathing in particles of arsenic contaminated soil as dust. Construction/excavation workers should always attempt to limit their exposure to bare soils, or lessen the time after contact that the impacted soil remains on the skin. Specific precautions to be taken at all times when soil is contacted are as follows:

1. Wear PPE (*i.e.,* as appropriate for each individual task), to limit the skin area available for contact with the soil, groundwater, sediment, and surface water (*i.e.*, disposable coveralls/Tyvek suits, safety boots, rubber over boots, safety goggles, and chemical-resistant/waterproof gloves).
2. Wash hands frequently, and always before eating, smoking, chewing gum or tobacco, or other activities that involve contact between the hands and items to be placed in the mouth. This will prevent the spread of any contaminants on the hands to the items being placed in the mouth.
3. Do not apply ointments, cream, make-up or other substances before washing both the area to which the substance is to be applied and, if the substance is to be applied by hand, the hands. The application of such substances can provide a mechanism by which contaminants can be trapped next to the skin.
4. Cover cuts, scrapes and other open skin areas. Injured skin allows compounds in the soil and groundwater to be more readily absorbed into the body than intact skin.

5. Wash hands and other exposed areas, especially those areas with visible dirt, before leaving the work site for extended time periods. This limits the amount of time that the soil, groundwater, sediment and/or surface water is potentially in contact with the skin, thereby reducing the amount of the chemicals that can be absorbed through the skin.

6. Change work clothes shortly after leaving the construction site, especially those work clothes having either visible dirt or made damp through sweat or other liquids. Wash such clothes prior to wearing them again. Gloves and other such items that come into direct contact with the soil, groundwater, sediment and/or surface water should also be washed, if possible. Work boots should be left at the facility or rubber over boots should be worn.

7. Wash hair and other less accessible portions of the body shortly after leaving the construction site for the day. Dirt and dust that contain substances such as arsenic can settle in the hair and spread by contact between the hands and the hair. Dirt and dust can also infiltrate under and through clothing, especially clothing becoming wet or sweaty.

8. Generally avoid direct contact between the skin and the contaminated soils, groundwater, sediment, and surface water.

9. Minimize the suspension of dust to the degree possible and specify measures to be taken for minimizing dust. Dust masks should be worn when warranted.

3.2 Actions to Take if Significant Exposures Occur

It is anticipated that work will be performed using Level D protection and that contaminant exclusion zones will not always be required; however, it is the responsibility of the construction/excavation worker or contractor to establish the proper level of protection for the planned activities by completing a job hazard analysis (JHA) prior to execution of the invasive activity. Exclusion zones may be utilized for convenience to properly segregate operations and keep unauthorized personnel out of work area. The JHA and associated HASP should contain the documentation of the proper procedures and chain of communication that should be followed in the event of an emergency and the appropriate emergency contacts.

Whenever significant exposures to contaminated soil, groundwater, sediment and/or surface water are suspected to have occurred at the Site, additional actions should be taken. In the event that construction/excavation workers experience significant increased exposures to soil, groundwater, sediment, and/or surface water, despite the mitigation measures and exposure precautions detailed above, the following steps must be taken:

1. Immediately remove contaminated clothing and decontaminate clothing and personnel by washing exposed areas, especially those with visible dirt.

2. Seek medical attention if adverse symptoms occur.

3. Restrict access to the contaminated area through temporary fencing, or limit/suspend worker in the area, as necessary and appropriate.

4. Perform sampling and analysis, as required, to determine levels of PPE, decontamination of personnel and equipment, training needs, medical surveillance and waste management requirements, prior to resuming work at the area.

3.3 Decontamination and Cleanup Procedures

3.3.1 Personnel Decontamination

All personnel will perform cleanup prior to leaving the construction work area(s). Under no circumstances, except for emergency evacuation, will contaminated personnel or equipment be allowed to leave a work area without first cleaning up. The following will be performed during personnel decontamination procedures:

1. tools, air monitoring equipment, samples and trash will be placed at designated stations (stations will be either plastic containers or drop sheets);
2. outer glove and boot wash;
3. tape and outer boot covers will be removed and placed in designated container;
4. outer gloves will be removed and placed in designated container;
5. hard hats will be removed and placed in designated area;
6. outer garments will be removed and discarded in designated container;
7. inner gloves will be removed and placed in designated container; and
8. respirator (if necessary) will be removed and placed in designated area.

3.3.2 Equipment Decontamination

It is the responsibility of construction or utility worker to ensure that all decontamination of equipment be conducted in a manner that assures all contaminants remain in their appropriate work zone and are properly stored (e.g., drums, covered with visqueen, etc.).

Monitoring equipment will be protected from contamination as much as possible. This may be done by draping with plastic, masking, or covering instruments with plastic bags so as not to hinder proper operation.

If required, respirators shall be cleaned daily with respirator disinfectant, alcohol, or other appropriate disinfecting solution wetted paper wipes. At the beginning of each day, masks will be inspected, repaired as necessary and re-assembled. New respirator cartridges will be installed before each shift or when breakthrough is suspected. Each person will be responsible for his or her own respirator adjustments, care and fit.

3.3.3 Work Zone Cleanup

The construction or utility worker will ensure that all work zones are left in a clean and orderly condition. All disposable clothing, excess materials, and other debris will remain at the decontamination/staging area in 55-gallon steel drums or roll-off boxes.

4.0 MANAGEMENT OF IMPACTED ENVIRONMENTAL MEDIA

When intrusive activities are completed at the Site such that soils are being excavated and moved, the environmental media must be appropriately managed and disposed of, as applicable.

4.1 Soil

If soils are being excavated and moved, the soil will be managed as follows:

1. The soil will be temporarily placed in roll-off boxes and covered. The soils will be characterized for proper disposition (*i.e.,* sampled and submitted to a laboratory for the appropriate chemical analyses), including on-site placement, transportation to a licensed treatment, storage or disposal facility, off-site relocation, or off-site use. These activities will be conducted in accordance with all applicable laws and regulations.

2. Personnel in the area of the excavation and stockpile who may encounter impacted soil will wear appropriate PPE, based on the magnitude of impact encountered, including respiratory equipment, if deemed necessary.

3. Personnel (*i.e.,* facility construction personnel or contractors) in the area of the excavation and roll-off boxes will wear appropriate PPE and respiratory equipment, if deemed necessary.

4. Based on the analytical results of the soil collected, appropriate procedures will be established to mitigate all risks based on the nature and duration of the work that will be conducted.

4.2 Groundwater

Groundwater is anticipated to be encountered at a depth as shallow as approximately 9 feet below ground surface (bgs) in west-northwest portion of the Site. Groundwater that accumulates within Site excavations (*i.e.,* runoff/groundwater) will be managed on-Site as follows:

1. All water which comes into contact with excavated soil shall be contained on-Site and pumped to the facility waste water treatment plant (WWTP), so as to prevent off-Site flow. The Owner shall be notified of the water management methods immediately. Work will not proceed in the area if standing water remains.

2. If storm water has infiltrated into the exposed area before work can proceed, the excess water will be pumped from the area to the WWTP.

3. All water encountered during work activities, including water removed from excavations, shall be contained on-Site and pumped to the facility WWTP.

4. All water generated from decontamination activities shall be disposed at the facility WWTP.

5. Make-up water used for drilling shall be re-circulated back through the borehole or collected, containerized, and sent to the on-Site WWTP for treatment.

6. Daily logs will be maintained that will identify the quantity and origin of all water added to any storage tank.

7. Based on the analytical results of the water collected, appropriate procedures will be established to mitigate all risks based on the nature and duration of the work that will be conducted.

4.3 Sediment and Surface Water

COCs detected in sediment and surface water were not determined to exceed acceptable hazard and risk goals for the construction/excavation workers. Therefore, specific management procedures for sediment and surface water from the unnamed tributary to Tinkers Creek are not necessary.

5.0 RISK MITIGATION PROVISIONS

The risk mitigation measures discussed herein are to be implemented at the two distinct areas of the Site as depicted on Figure 3. This will also ensure protection of construction/excavation workers and contractors, who may conduct intrusive activities at the Site, from exposures to soils containing concentrations of arsenic above its respective background concentration and applicable hazard and risk goals, concentrations of trichloroethene in groundwater above applicable hazard and risk goals, as well as exposures to sediment and surface water in the unnamed tributary to Tinkers Creek.

These risk mitigation measures should be periodically reviewed to assure their effectiveness and should be revised, as needed, based on any changes in operations and worker activities, any potential additional investigation results, and the implementation of any remedial activities conducted as part of the Administrative Order on Consent (Docket No. RCRA-05-2011-0020) (Consent Order).

5.1 General Provisions: Restrict Site Access

The Site is currently fenced and should be maintained in order to preclude exposure to on-Site soils by trespassers. Regular inspection of the facility perimeter fencing is recommended in order to identify areas of the fence that may have been damaged or breached; any damage should be repaired within a reasonable timeframe of discovery.

5.2 Notice Provisions

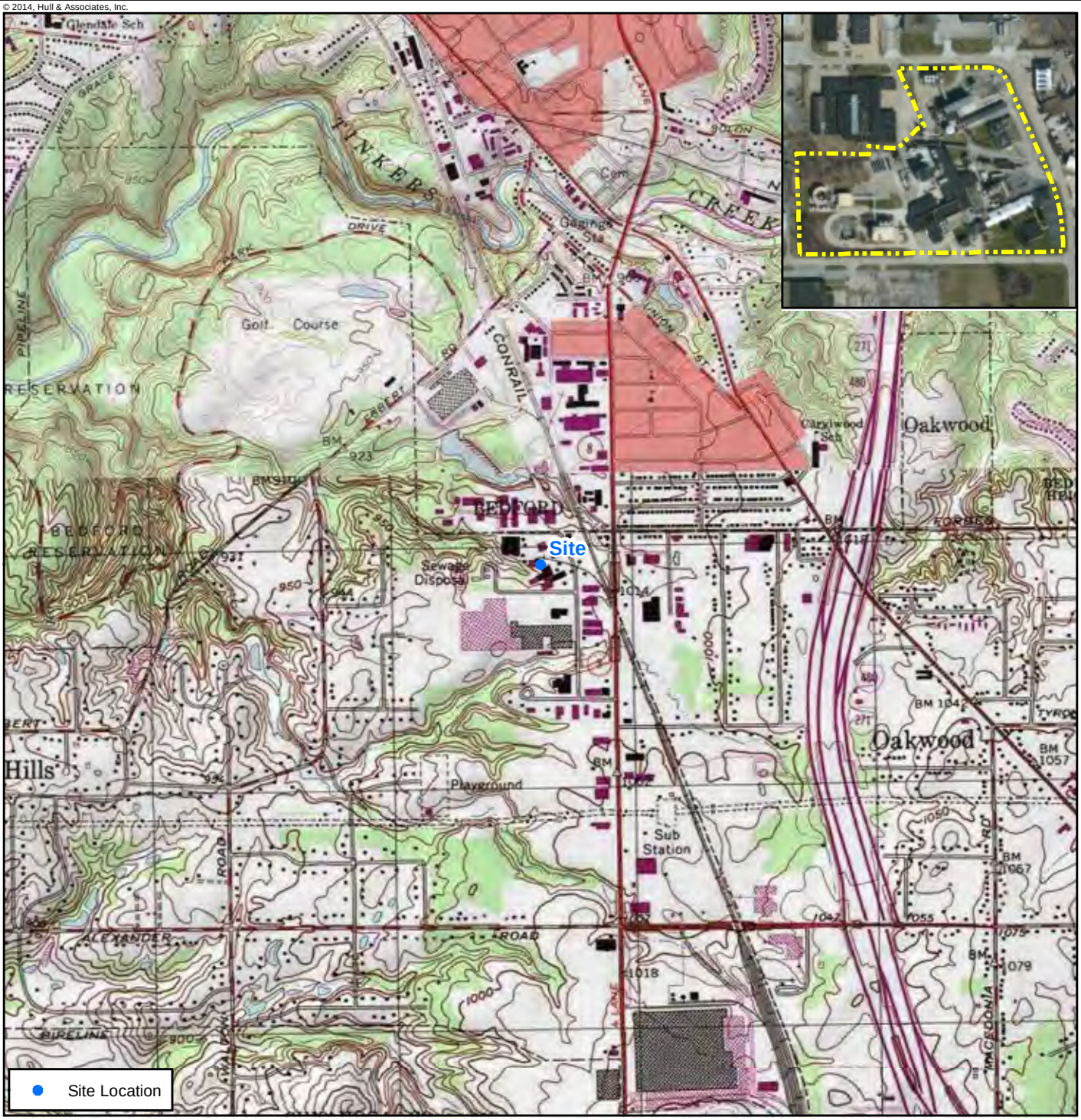
Whenever construction/excavation workers or contractors are reasonably expected to be exposed to soils, groundwater, sediment and/or surface water, the owner of the Site is responsible for communicating all the information provided in this RMP to the affected workers. The owner is to communicate the identity of the COCs present on the Site (*i.e.,* namely arsenic in soil and trichloroethene in groundwater), the potential health effects associated with exposure to said chemicals, the precautions to be taken to avoid exposure, how to handle contaminated media on the Site, and actions to be taken should significant exposure occur.

A copy of this RMP will be maintained at the Site. The Site owner will ensure that the plan is made available to construction/excavation workers and contractors and will ensure that the risk mitigation measures are implemented when work occurs.

5.3 Termination of the Risk Mitigation Plan

This RMP simply outlines risk mitigation measures to protect construction/excavation workers and contractors who may be involved in intrusive activities at the Site. Throughout the course of the Consent Order, these risk mitigation measures should be periodically reviewed to assure their effectiveness and should be revised, as needed, based on any changes in operations and worker activities, any potential additional subsurface investigation results, and the implementation of any remedial activities.

FIGURES



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0 500 1,000 2,000 Feet

1:24,000

Quad: Northfield

Source: The topographic map was acquired through the USGS Topographic Map web service.

The aerial photo in the inset was acquired through the ESRI Imagery web service. Aerial photography dated 2012.

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Risk Mitigation Plan
Ferro Corporation

Site Location Map

7050 Knick Rd
Walton Hills, Cuyahoga County, Ohio

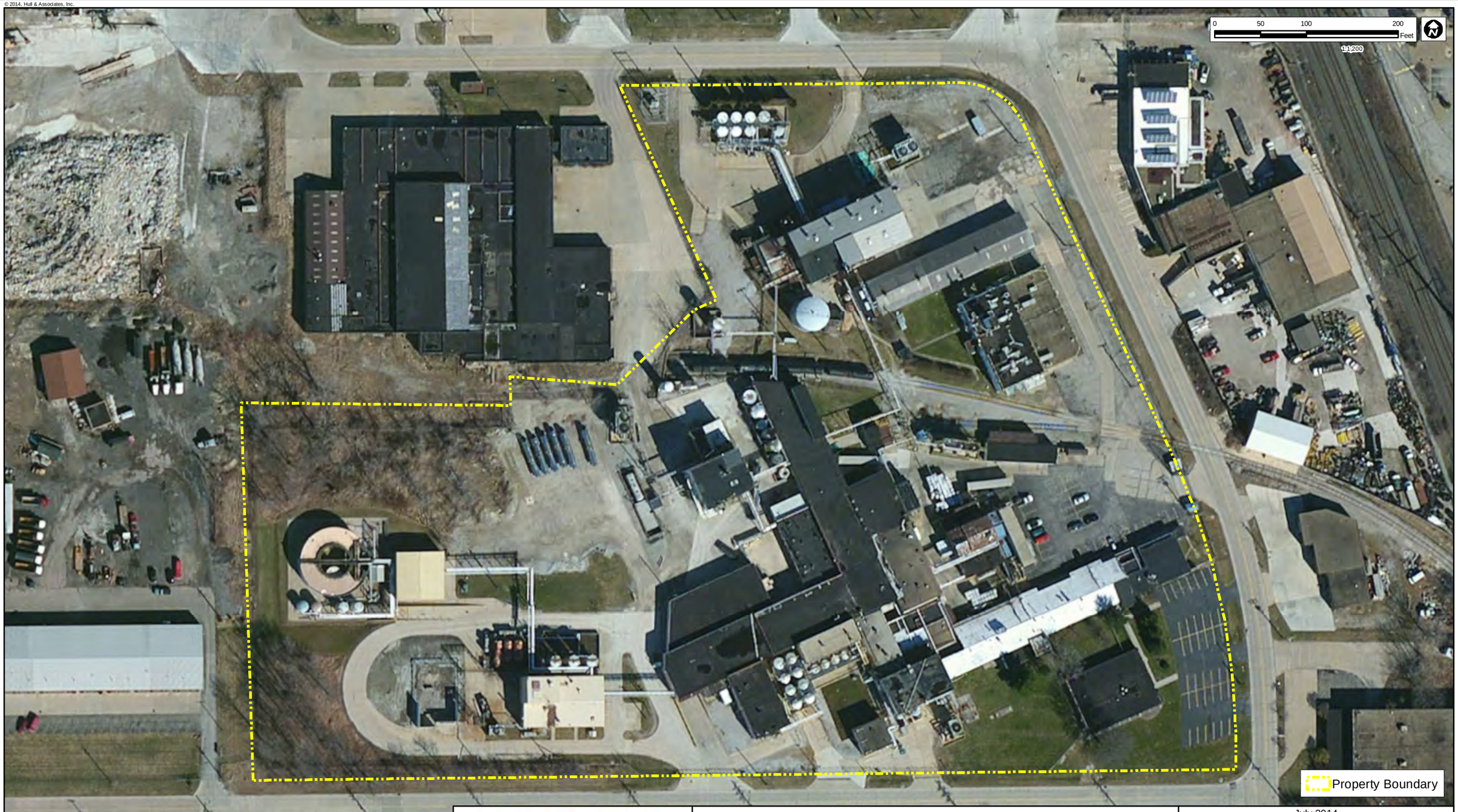
Date:
July 2014

File Name:
FCO028_11_Fig01_SLM.mxd

Edited: 7/10/2014 By: mopel

Figure
1

Produced using ArcGIS 10.0 SP1



Notes:
The aerial photo was acquired through the ESRI Imagery web service. Aerial photography dated 2012.

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July 2014

Risk Mitigation Plan
Ferro Corporation

Site Layout

7050 Knick Rd
Walton Hills, Cuyahoga County, Ohio

Figure 2

Produced using ArcGIS 10.0 SP1
File Name: FCO028_11_Fig02_SiteLayout.mxd
Edited: 7/10/2014 By: mopel

Risk Management Area A; trichloroethene in groundwater was detected above acceptable human health risk goals in this general area.
Risk Management Area B; a single concentration of arsenic in soil was detected above it's respective background concentration in this area.

0 50 100 200 Feet
1:1,200

HMW-6 SB21-3 SB21-6 SB21-2 SB21-1 SB21-5 SB21-4
SBa2-3 SBa2-2 SBa2-1 HVP-7 HMW-7 HVP-6 SB3-1 SB3-4 SB3-3 SB3-2 HMW-8
SB7-3 SB7-1 HMW-4 SB7-4 SB7-2
SB-3/3A HVP-1 HMW-13 HMW-12 SW-5 SD-2 SW-4 SW-3 SD-1 HMW-3 SB14-6 HVP-2 SB14-2 SB14-4 SB14-3 SB14-8 SB14-7 HMW-11 SW-2 SB14-1 SB14-5 HMW-10
HMW-5 SB22-3 SB22-2 HVP-5
HMW-2 SB24-1 SB24-2 HVP-3 SB24-3
SW-1
SB11-5 HMW-9 SB11-4 SB11-1 SB11-3 SB11-2
SBa1-2 SBa1-1 HVP-4 SBa1-3 HMW-1

Property Boundary
Monitoring Well
Sample Point
Sediment Sample
Soil Boring
Vapor Probe
Risk Management Area A
Risk Management Area B

Notes:
The aerial photo was acquired through the ESRI Imagery web service. Aerial photography dated 2012.

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July 2014

Risk Mitigation Plan
Ferro Corporation

Summary of Risk Management Areas

7050 Knick Rd
Walton Hills, Cuyahoga County, Ohio

Figure 3

Produced using ArcGIS 10.0 SP1

File Name: FCO028_11_Fig03_RiskMgmtAreas.mxd

Edited: 7/10/2014 By: mopel

APPENDIX A

ATSDR ToxFAQs

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

1,2-DICHLOROETHENE
CAS # 540-59-0, 156-59-2, and 156-60-5

This fact sheet answers the most frequently asked health questions (FAQs) about 1,2-dichloroethene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to 1,2-dichloroethene occurs mainly in workplaces where it is made or used. Breathing high levels of 1,2-dichloroethene can make you feel nauseous, drowsy, and tired. *cis*-1,2-Dichloroethene has been found in at least 146 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA). *trans*-1,2-Dichloroethene was found in at least 563 NPL sites. 1,2-Dichloroethene was found at 336 sites, but the isomer (*cis*- or *trans*-) was not specified.

What is 1,2-dichloroethene?

(Pronounced 1,2-dī-klôrʹ ō-ĕthʹēn)

1,2-Dichloroethene, also called 1,2-dichloroethylene, is a highly flammable, colorless liquid with a sharp, harsh odor. It is used to produce solvents and in chemical mixtures. You can smell very small amounts of 1,2-dichloroethene in air (about 17 parts of 1,2-dichloroethene per million parts of air [17 ppm]).

There are two forms of 1,2-dichloroethene; one is called *cis*-1,2-dichloroethene and the other is called *trans*-1,2-dichloroethene. Sometimes both forms are present as a mixture.

What happens to 1,2-dichloroethene when it enters the environment?

- 1,2-Dichloroethene evaporates rapidly into air.
- In the air, it takes about 5-12 days for half of it to break down.
- Most 1,2-dichloroethene in the soil surface or bodies of water will evaporate into air.
- 1,2-Dichloroethene can travel through soil or dissolve in water in the soil. It is possible that it can contaminate groundwater.
- In groundwater, it takes about 13-48 weeks to break down.
- There is a slight chance that 1,2-dichloroethene will break down into vinyl chloride, a different chemical which is believed to be more toxic than 1,2-dichloroethene.

How might I be exposed to 1,2-dichloroethene?

- Breathing 1,2-dichloroethene that has leaked from hazardous waste sites and landfills.
- Drinking contaminated tap water or breathing vapors from contaminated water while cooking, bathing, or washing dishes.
- Breathing 1,2-dichloroethene, touching it, or touching contaminated materials in the workplace.

How can 1,2-dichloroethene affect my health?

Breathing high levels of 1,2-dichloroethene can make you feel nauseous, drowsy, and tired; breathing very high levels can kill you.

When animals breathed high levels of *trans*-1,2-dichloroethene for short or longer periods of time, their livers and lungs were damaged and the effects were more severe with longer exposure times. Animals that breathed very high

levels of *trans*-1,2-dichloroethene had damaged hearts.

Animals that ingested extremely high doses of *cis*- or *trans*-1,2-dichloroethene died.

Lower doses of *cis*-1,2-dichloroethene caused effects on the blood, such as decreased numbers of red blood cells, and also effects on the liver.

The long-term (365 days or longer) human health effects after exposure to low concentrations of 1,2-dichloroethene aren't known. One animal study suggested that an exposed fetus may not grow as quickly as one that hasn't been exposed.

Exposure to 1,2-dichloroethene hasn't been shown to affect fertility in people or animals.

How likely is 1,2-dichloroethene to cause cancer?

The EPA has determined that *cis*-1,2-dichloroethene is not classifiable as to its human carcinogenicity.

No EPA cancer classification is available for *trans*-1,2-dichloroethene.

Is there a medical test to show whether I've been exposed to 1,2-dichloroethene?

Tests are available to measure concentrations of the breakdown products of 1,2-dichloroethene in blood, urine, and tissues. However, these tests aren't used routinely to determine whether a person has been exposed to this compound. This is because after you are exposed to 1,2-dichloroethene, the breakdown products in your body that are detected with these tests may be the same as those that come from exposure to other chemicals. These tests aren't available in most doctors' offices, but can be done at special laboratories that have the right equipment.

Has the federal government made recommendations to protect human health?

The EPA has set the maximum allowable level of *cis*-1,2-dichloroethene in drinking water at 0.07 milligrams per liter of water (0.07 mg/L) and *trans*-1,2-dichloroethene at 0.1 mg/L.

The EPA requires that any spills or accidental release of 1,000 pounds or more of 1,2-dichloroethene must be reported to the EPA.

The Occupational Health Safety and Health Administration (OSHA) has set the maximum allowable amount of 1,2-dichloroethene in workroom air during an 8-hour workday in a 40-hour workweek at 200 parts of 1,2-dichloroethene per million parts of air (200 ppm).

Glossary

Carcinogenicity: Ability of a substance to cause cancer.

CAS: Chemical Abstracts Service.

Fertility: Ability to reproduce.

Ingest: To eat or drink something.

Milligram (mg): One thousandth of a gram.

ppm: Parts per million.

Solvent: A chemical that can dissolve other substances.

References

This ToxFAQs information is taken from the 1996 Toxicological Profile for 1,2-Dichloroethene produced by the Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

PUBLIC HEALTH STATEMENT
Arsenic
CAS#: 7440-38-2

Division of Toxicology and Environmental Medicine **August 2007**

This Public Health Statement is the summary chapter from the Toxicological Profile for Arsenic. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-800-232-4636.

This public health statement tells you about arsenic and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Arsenic has been found in at least 1,149 of the 1,684 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which arsenic is found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to this substance may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to arsenic, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS ARSENIC?

Arsenic is a naturally occurring element that is widely distributed in the Earth's crust. Arsenic is classified chemically as a metalloid, having both properties of a metal and a nonmetal; however, it is frequently referred to as a metal. Elemental arsenic (sometimes referred to as metallic arsenic) is a steel grey solid material. However, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. Arsenic combined with carbon and hydrogen is referred to as organic arsenic.

Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no special taste. Thus, you usually cannot tell if arsenic is present in your food, water, or air.

Inorganic arsenic occurs naturally in soil and in many kinds of rock, especially in minerals and ores that contain copper or lead. When these ores are heated in smelters, most of the arsenic goes up the stack and enters the air as a fine dust. Smelters may collect this dust and take out the arsenic as a compound called arsenic trioxide (As_2O_3).

However, arsenic is no longer produced in the United States; all of the arsenic used in the United States is imported.

Presently, about 90% of all arsenic produced is used as a preservative for wood to make it resistant to rotting and decay. The preservative is copper chromated arsenate (CCA) and the treated wood is referred to as "pressure-treated." In 2003, U.S. manufacturers of wood preservatives containing arsenic began a voluntary transition from CCA to other wood preservatives that do not contain arsenic in wood products for certain residential uses, such as play structures, picnic tables, decks, fencing, and boardwalks. This phase out was completed on December 31, 2003; however, wood treated prior to this date could still be used and existing structures made with CCA-treated wood would not be affected. CCA-treated wood products continue to be used in industrial applications. It is not known whether, or to what extent, CCA-treated wood products may contribute to exposure of people to arsenic.

In the past, inorganic arsenic compounds were predominantly used as pesticides, primarily on cotton fields and in orchards. Inorganic arsenic compounds can no longer be used in agriculture. However, organic arsenic compounds, namely cacodylic acid, disodium methylarsenate (DSMA), and monosodium methylarsenate (MSMA), are still used as pesticides, principally on cotton. Some organic arsenic compounds are used as additives in animal feed. Small quantities of elemental arsenic are added to other metals to form metal mixtures or alloys with improved properties. The greatest use of arsenic in alloys is in lead-acid batteries for automobiles. Another important use of arsenic compounds is in semiconductors and light-emitting diodes.

1.2 WHAT HAPPENS TO ARSENIC WHEN IT ENTERS THE ENVIRONMENT?

Arsenic occurs naturally in soil and minerals and it therefore may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Volcanic eruptions are another source of arsenic. Arsenic is associated with ores containing metals, such as copper and lead. Arsenic may enter the environment during the mining and smelting of these ores. Small amounts of arsenic also may be released into the atmosphere from coal-fired power plants and incinerators because coal and waste products often contain some arsenic.

Arsenic cannot be destroyed in the environment. It can only change its form, or become attached to or separated from particles. It may change its form by reacting with oxygen or other molecules present in air, water, or soil, or by the action of bacteria that live in soil or sediment. Arsenic released from power plants and other combustion processes is usually attached to very small particles. Arsenic contained in wind-borne soil is generally found in larger particles. These particles settle to the ground or are washed out of the air by rain. Arsenic that is attached to very small particles may stay in the air for many days and travel long distances. Many common arsenic compounds can dissolve in water. Thus, arsenic can get into lakes, rivers, or underground water by dissolving in rain or snow or through the discharge of industrial wastes. Some of the arsenic will stick to particles in the water or sediment on the bottom of lakes or rivers, and some

will be carried along by the water. Ultimately, most arsenic ends up in the soil or sediment. Although some fish and shellfish take in arsenic, which may build up in tissues, most of this arsenic is in an organic form called arsenobetaine (commonly called "fish arsenic") that is much less harmful.

1.3 HOW MIGHT I BE EXPOSED TO ARSENIC?

Since arsenic is found naturally in the environment, you will be exposed to some arsenic by eating food, drinking water, or breathing air. Children may also be exposed to arsenic by eating soil. Analytical methods used by scientists to determine the levels of arsenic in the environment generally do not determine the specific form of arsenic present. Therefore, we do not always know the form of arsenic a person may be exposed to. Similarly, we often do not know what forms of arsenic are present at hazardous waste sites. Some forms of arsenic may be so tightly attached to particles or embedded in minerals that they are not taken up by plants and animals.

The concentration of arsenic in soil varies widely, generally ranging from about 1 to 40 parts of arsenic to a million parts of soil (ppm) with an average level of 3–4 ppm. However, soils in the vicinity of arsenic-rich geological deposits, some mining and smelting sites, or agricultural areas where arsenic pesticides had been applied in the past may contain much higher levels of arsenic. The concentration of arsenic in natural surface and groundwater is generally about 1 part in a billion parts of water (1 ppb), but may exceed 1,000 ppb in contaminated areas or where arsenic levels in soil are high. Groundwater is far more likely to contain high levels of arsenic than surface water. Surveys of U.S. drinking water indicate that about 80% of water supplies have less than 2 ppb of arsenic, but 2% of supplies exceed 20 ppb of arsenic. Levels of arsenic in food range from about 20 to 140 ppb. However, levels of inorganic arsenic, the form of most concern, are far lower. Levels of arsenic in the air generally range from less than 1 to about 2,000 nanograms (1 nanogram equals a billionth of a gram) of arsenic per cubic meter of air (less than 1–2,000 ng/m^3), depending on location, weather conditions, and the level of industrial activity in the area. However, urban areas generally have mean arsenic levels in air ranging from 20 to 30 ng/m^3.

You normally take in small amounts of arsenic in the air you breathe, the water you drink, and the food you eat. Of these, food is usually the largest source of arsenic. The predominant dietary source of arsenic is seafood, followed by rice/rice cereal, mushrooms, and poultry. While seafood contains the greatest amounts of arsenic, for fish and shellfish, this is mostly in an organic form of arsenic called arsenobetaine that is much less harmful. Some seaweeds may contain arsenic in inorganic forms that may be more harmful. Children are likely to eat small amounts of dust or soil each day, so this is another way they may be exposed to arsenic. The total amount of arsenic you take in from these sources is generally about 50 micrograms (1 microgram equals one-millionth of a gram) each day. The level of inorganic arsenic (the form of most concern) you take in from these sources is generally about 3.5 microgram/day. Children may be exposed to small amounts of arsenic from hand-to-mouth activities from playing on play structures or decks constructed out of CCA-treated wood. The potential exposure that children

may receive from playing in play structures constructed from CCA-treated wood is generally smaller than that they would receive from food and water.

In addition to the normal levels of arsenic in air, water, soil, and food, you could be exposed to higher levels in several ways, such as the following:

- Some areas of the United States contain unusually high natural levels of arsenic in rock, and this can lead to unusually high levels of arsenic in soil or water. If you live in an area like this, you could take in elevated amounts of arsenic in drinking water. Children may be taking in higher amounts of arsenic because of hand-to-mouth contact or eating soil in areas with higher than usual arsenic concentrations.

- Some hazardous waste sites contain large quantities of arsenic. If the material is not properly disposed of, it can get into surrounding water, air, or soil. If you live near such a site, you could be exposed to elevated levels of arsenic from these media.

- If you work in an occupation that involves arsenic production or use (for example, copper or lead smelting, wood treating, or pesticide application), you could be exposed to elevated levels of arsenic during your work.

- If you saw or sand arsenic-treated wood, you could inhale some of the sawdust into your nose or throat. Similarly, if you burn arsenic-treated wood, you could inhale arsenic in the smoke.

- If you live in a former agricultural area where arsenic was used on crops, the soil could contain high levels of arsenic.

- In the past, several kinds of products used in the home (rat poison, ant poison, weed killer, some types of medicines) had arsenic in them. However, most of these uses of arsenic have ended, so you are not likely to be exposed from home products any longer.

1.4 HOW CAN ARSENIC ENTER AND LEAVE MY BODY?

If you swallow arsenic in water, soil, or food, most of the arsenic may quickly enter into your body. The amount that enters your body will depend on how much you swallow and the kind of arsenic that you swallow. This is the most likely way for you to be exposed near a waste site. If you breathe air that contains arsenic dusts, many of the dust particles settle onto the lining of the lungs. Most of the arsenic in these particles is then taken up from the lungs into the body. You might be exposed in this way near waste sites where arsenic-contaminated soils are allowed to blow into the air, or if you work with arsenic-containing soil or products. If you get arsenic-contaminated soil or water on your skin, only a small amount will go through your skin into your body, so this is usually not of concern.

Both inorganic and organic forms leave your body in your urine. Most of the inorganic arsenic will be gone within several days, although some will remain in your body for several months or even longer. If you are exposed to organic arsenic, most of it will leave your body within several days.

1.5 HOW CAN ARSENIC AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals.

Inorganic arsenic has been recognized as a human poison since ancient times, and large oral doses (above 60,000 ppb in water which is 10,000 times higher than 80% of U.S. drinking water arsenic levels) can result in death. If you swallow lower levels of inorganic arsenic (ranging from about 300 to 30,000 ppb in water; 100–10,000 times higher than most U.S. drinking water levels), you may experience irritation of your stomach and intestines, with symptoms such as stomachache, nausea, vomiting, and diarrhea. Other effects you might experience from swallowing inorganic arsenic include decreased production of red and white blood cells, which may cause fatigue, abnormal heart rhythm, blood-vessel damage resulting in bruising, and impaired nerve function causing a "pins and needles" sensation in your hands and feet.

Perhaps the single-most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. These include patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles, and torso, and are often associated with changes in the blood vessels of the skin. Skin cancer may also develop. Swallowing arsenic has also been reported to increase the risk of cancer in the liver, bladder, and lungs. The Department of Health and Human Services (DHHS) has determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer). The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans. EPA also has classified inorganic arsenic as a known human carcinogen.

If you breathe high levels of inorganic arsenic, then you are likely to experience a sore throat and irritated lungs. You may also develop some of the skin effects mentioned above. The exposure level that produces these effects is uncertain, but it is probably above 100 micrograms of arsenic per cubic meter ($\mu g/m^3$) for a brief exposure. Longer exposure at lower concentrations can lead to skin effects, and also to circulatory and peripheral nervous disorders. There are some data suggesting that inhalation of inorganic arsenic may also

interfere with normal fetal development, although this is not certain. An important concern is the ability of inhaled inorganic arsenic to increase the risk of lung cancer. This has been seen mostly in workers exposed to arsenic at smelters, mines, and chemical factories, but also in residents living near smelters and arsenical chemical factories. People who live near waste sites with arsenic may have an increased risk of lung cancer as well.

If you have direct skin contact with high concentrations of inorganic arsenic compounds, your skin may become irritated, with some redness and swelling. However, it does not appear that skin contact is likely to lead to any serious internal effects.

Almost no information is available on the effects of organic arsenic compounds in humans. Studies in animals show that most simple organic arsenic compounds (such as methyl and dimethyl compounds) are less toxic than the inorganic forms. In animals, ingestion of methyl compounds can result in diarrhea, and lifetime exposure can damage the kidneys. Lifetime exposure to dimethyl compounds can damage the urinary bladder and the kidneys.

1.6 HOW CAN ARSENIC AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

Children are exposed to arsenic in many of the same ways that adults are. Since arsenic is found in the soil, water, food, and air, children may take in arsenic in the air they breathe, the water they drink, and the food they eat. Since children tend to eat or drink less of a variety of foods and beverages than do adults, ingestion of contaminated food or juice or infant formula made with arsenic-contaminated water may represent a significant source of exposure. In addition, since children often play in the soil and put their hands in their mouths and sometimes intentionally eat soil, ingestion of contaminated soil may be a more important source of arsenic exposure for children than for adults. In areas of the United States where natural levels of arsenic in the soil and water are high, or in areas in and around contaminated waste sites, exposure of children to arsenic through ingestion of soil and water may be significant. In addition, contact with adults who are wearing clothes contaminated with arsenic (e.g., with dust from copper- or lead-smelting factories, from wood-treating or pesticide application, or from arsenic-treated wood) could be a source of exposure. Because of the tendency of children to taste things that they find, accidental poisoning from ingestion of pesticides is also a possibility. Thus, although most of the exposure pathways for children are the same as those for adults, children may be at a higher risk of exposure because of normal hand-to-mouth activity.

Children who are exposed to inorganic arsenic may have many of the same effects as adults, including irritation of the stomach and intestines, blood vessel damage, skin changes, and reduced nerve function. Thus, all health effects observed in adults are of potential concern in children. There is also some evidence that suggests that long-term exposure to inorganic arsenic in children may result in lower IQ scores. We do not know if absorption of inorganic arsenic from the gut in children differs from adults.

There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults.

There is some evidence that inhaled or ingested inorganic arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of inorganic arsenic that cause illness in pregnant females can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

In animals, exposure to organic arsenic compounds can cause low birth weight, fetal malformations, and fetal deaths. The dose levels that cause these effects also result in effects in the mothers.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO ARSENIC?

If your doctor finds that you have been exposed to substantial amounts of arsenic, ask whether your children might also have been exposed. Your doctor might need to ask your state health department to investigate.

Many communities may have high levels of arsenic in their drinking water, particularly from private wells, because of contamination or as a result of the geology of the area. The north central region and the western region of the United States have the highest arsenic levels in surface water and groundwater sources, respectively. Wells used to provide water for drinking and cooking should be tested for arsenic. As of January 2006, EPA's Maximum Contaminant Level (MCL) for arsenic in drinking water is 10 ppb. If you have arsenic in your drinking water at levels higher that the EPA's MCL, an alternative source of water should be used for drinking and cooking should be considered.

If you use arsenic-treated wood in home projects, personal protection from exposure to arsenic-containing sawdust may be helpful in limiting exposure of family members. These measures may include dust masks, gloves, and protective clothing. Arsenic-treated wood should never be burned in open fires, or in stoves, residential boilers, or fire places, and should not be composted or used as mulch. EPA's Consumer Awareness Program (CAP) for CCA is a voluntary program established by the manufacturers of CCA products to inform consumers about the proper handling, use, and disposal of CCA-treated wood. You can find more information about this program in Section 6.5. Hand washing can reduce the potential exposure of children to arsenic after playing on play structures constructed with CCA-treated wood, since most of the arsenic on the children's hands was removed with water.

If you live in an area with a high level of arsenic in the water or soil, substituting cleaner sources of water and limiting contact with soil (for example, through use of a dense groundcover or thick lawn) would reduce family exposure to arsenic. By paying careful attention to dust and soil control in the home (air filters, frequent cleaning), you can reduce family exposure to contaminated soil. Some children eat a lot of soil. You should prevent your children from eating soil. You should discourage your children from putting objects in their mouths. Make sure they wash their hands frequently and

before eating. Discourage your children from putting their hands in their mouths or engaging in other hand-to-mouth activities. Since arsenic may be found in the home as a pesticide, household chemicals containing arsenic should be stored out of reach of young children to prevent accidental poisonings. Always store household chemicals in their original labeled containers; never store household chemicals in containers that children would find attractive to eat or drink from, such as old soda bottles. Keep your Poison Control Center's number by the phone.

It is sometimes possible to carry arsenic from work on your clothing, skin, hair, tools, or other objects removed from the workplace. This is particularly likely if you work in the fertilizer, pesticide, glass, or copper/lead smelting industries. You may contaminate your car, home, or other locations outside work where children might be exposed to arsenic. You should know about this possibility if you work with arsenic.

Your occupational health and safety officer at work can and should tell you whether chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes. Material safety data sheets (MSDS) for many chemicals used should be found at your place of work, as required by the Occupational Safety and Health Administration (OSHA) in the U.S. Department of Labor. MSDS information should include chemical names and hazardous ingredients, and important properties, such as fire and explosion data, potential health effects, how you get the chemical(s) in your body, how to properly handle the materials, and what to do in the case of emergencies. Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Your state OSHA-approved occupational safety and health program or OSHA can answer any further questions and help your employer identify and correct problems with hazardous substances. Your state OSHA-approved occupational safety and health program or OSHA will listen to your formal complaints about workplace health hazards and inspect your workplace when necessary. Employees have a right to seek safety and health on the job without fear of punishment.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO ARSENIC?

Several sensitive and specific tests can measure arsenic in your blood, urine, hair, or fingernails, and these tests are often helpful in determining if you have been exposed to above-average levels of arsenic in the past. These tests are not usually performed in a doctor's office. They require sending the sample to a testing laboratory.

Measurement of arsenic in your urine is the most reliable means of detecting arsenic exposures that you experienced within the last several days. Most tests measure the total amount of arsenic present in your urine. This can sometimes be misleading, because the nonharmful forms of arsenic in fish and shellfish can give a high reading even if you have not been exposed to a toxic form of arsenic. For this reason, laboratories sometimes use a more

complicated test to separate "fish arsenic" from other forms. Because most arsenic leaves your body within a few days, analysis of your urine cannot detect if you were exposed to arsenic in the past. Tests of your hair or fingernails can tell if you were exposed to high levels over the past 6–12 months, but these tests are not very useful in detecting low-level exposures. If high levels of arsenic are detected, this shows that you have been exposed, but unless more is known about when you were exposed and for how long, it is usually not possible to predict whether you will have any harmful health effects.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for ARSENIC include the following:

The federal government has taken several steps to protect humans from arsenic. First, EPA has set limits on the amount of arsenic that industrial sources can release into the environment. Second, EPA has restricted or canceled many of the uses of arsenic in pesticides and is considering further restrictions. Third, in January 2001, the EPA lowered the limit for arsenic in drinking water from 50 to 10 ppb. Finally, OSHA has established a permissible exposure limit (PEL), 8-hour time-weighted average, of 10 $\mu g/m^3$ for airborne arsenic in various workplaces that use inorganic arsenic.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating,

and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are also available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636), by e-mail at cdcinfo@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Environmental Medicine
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

Organizations for-profit may request copies of final Toxicological Profiles from the following:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: http://www.ntis.gov/

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

ARSENIC

CAS # 7440-38-2

Division of Toxicology and Environmental Medicine ToxFAQs™ **August 2007**

This fact sheet answers the most frequently asked health questions (FAQs) about arsenic. For more information, call the ATSDR Information Center at 1-800-232-4636. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to higher than average levels of arsenic occur mostly in the workplace, near hazardous waste sites, or in areas with high natural levels. At high levels, inorganic arsenic can cause death. Exposure to lower levels for a long time can cause a discoloration of the skin and the appearance of small corns or warts. Arsenic has been found in at least 1,149 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is arsenic?

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds.

Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenate (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards.

What happens to arsenic when it enters the environment?

❑ Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching.
❑ Arsenic cannot be destroyed in the environment. It can only change its form.
❑ Rain and snow remove arsenic dust particles from the air.
❑ Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment.
❑ Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine that is much less harmful.

How might I be exposed to arsenic?

❑ Ingesting small amounts present in your food and water or breathing air containing arsenic.
❑ Breathing sawdust or burning smoke from wood treated with arsenic.
❑ Living in areas with unusually high natural levels of arsenic in rock.
❑ Working in a job that involves arsenic production or use, such as copper or lead smelting, wood treating, or pesticide application.

How can arsenic affect my health?

Breathing high levels of inorganic arsenic can give you a sore throat or irritated lungs.

Ingesting very high levels of arsenic can result in death. Exposure to lower levels can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.

Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.

Skin contact with inorganic arsenic may cause redness and swelling.

ToxFAQs™ Internet address is http://www.atsdr.cdc.gov/toxfaq.html

Almost nothing is known regarding health effects of organic arsenic compounds in humans. Studies in animals show that some simple organic arsenic compounds are less toxic than inorganic forms. Ingestion of methyl and dimethyl compounds can cause diarrhea and damage to the kidneys

How likely is arsenic to cause cancer?

Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer. The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans.

How can arsenic affect children?

There is some evidence that long-term exposure to arsenic in children may result in lower IQ scores. There is also some evidence that exposure to arsenic in the womb and early childhood may increase mortality in young adults.

There is some evidence that inhaled or ingested arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of arsenic that cause illness in pregnant females, can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

How can families reduce the risks of exposure to arsenic?

❑ If you use arsenic-treated wood in home projects, you should wear dust masks, gloves, and protective clothing to decrease exposure to sawdust.

❑ If you live in an area with high levels of arsenic in water or soil, you should use cleaner sources of water and limit contact with soil.

❑ If you work in a job that may expose you to arsenic, be aware that you may carry arsenic home on your clothing, skin, hair, or tools. Be sure to shower and change clothes before going home.

Is there a medical test to determine whether I've been exposed to arsenic?

There are tests available to measure arsenic in your blood, urine, hair, and fingernails. The urine test is the most reliable test for arsenic exposure within the last few days. Tests on hair and fingernails can measure exposure to high levels of arsenic over the past 6-12 months. These tests can determine if you have been exposed to above-average levels of arsenic. They cannot predict whether the arsenic levels in your body will affect your health.

Has the federal government made recommendations to protect human health?

The EPA has set limits on the amount of arsenic that industrial sources can release to the environment and has restricted or cancelled many of the uses of arsenic in pesticides. EPA has set a limit of 0.01 parts per million (ppm) for arsenic in drinking water.

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) of 10 micrograms of arsenic per cubic meter of workplace air (10 $\mu g/m^3$) for 8 hour shifts and 40 hour work weeks.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological Profile for Arsenic (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-800-232-4636, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

TETRACHLOROETHYLENE
CAS # 127-18-4

This fact sheet answers the most frequently asked health questions (FAQs) about tetrachloroethylene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Tetrachloroethylene is a manufactured chemical used for dry cleaning and metal degreasing. Exposure to very high concentrations of tetrachloroethylene can cause dizziness, headaches, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Tetrachloroethylene has been found in at least 771 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is tetrachloroethylene?

(Pronounced tĕt′rə-klôr′ ō-ĕth′ə-lēn′)

Tetrachloroethylene is a manufactured chemical that is widely used for dry cleaning of fabrics and for metal-degreasing. It is also used to make other chemicals and is used in some consumer products.

Other names for tetrachloroethylene include perchloroethylene, PCE, and tetrachloroethene. It is a nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell tetrachloroethylene when it is present in the air at a level of 1 part tetrachloroethylene per million parts of air (1 ppm) or more, although some can smell it at even lower levels.

What happens to tetrachloroethylene when it enters the environment?

- Much of the tetrachloroethylene that gets into water or soil evaporates into the air.
- Microorganisms can break down some of the tetrachloroethylene in soil or underground water.
- In the air, it is broken down by sunlight into other chemicals or brought back to the soil and water by rain.
- It does not appear to collect in fish or other animals that live in water.

How might I be exposed to tetrachloroethylene?

- When you bring clothes from the dry cleaners, they will release small amounts of tetrachloroethylene into the air.
- When you drink water containing tetrachloroethylene, you are exposed to it.

How can tetrachloroethylene affect my health?

High concentrations of tetrachloroethylene (particularly in closed, poorly ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death.

Irritation may result from repeated or extended skin contact with it. These symptoms occur almost entirely in work (or hobby) environments when people have been accidentally exposed to high concentrations or have intentionally used tetrachloroethylene to get a "high."

In industry, most workers are exposed to levels lower than those causing obvious nervous system effects. The health effects of breathing in air or drinking water with low levels of tetrachloroethylene are not known.

Results from some studies suggest that women who work in dry cleaning industries where exposures to tetrachloroethyl-

ene can be quite high may have more menstrual problems and spontaneous abortions than women who are not exposed. However, it is not known if tetrachloroethylene was responsible for these problems because other possible causes were not considered.

Results of animal studies, conducted with amounts much higher than those that most people are exposed to, show that tetrachloroethylene can cause liver and kidney damage. Exposure to very high levels of tetrachloroethylene can be toxic to the unborn pups of pregnant rats and mice. Changes in behavior were observed in the offspring of rats that breathed high levels of the chemical while they were pregnant.

How likely is tetrachloroethylene to cause cancer?

The Department of Health and Human Services (DHHS) has determined that tetrachloroethylene may reasonably be anticipated to be a carcinogen. Tetrachloroethylene has been shown to cause liver tumors in mice and kidney tumors in male rats.

Is there a medical test to show whether I've been exposed to tetrachloroethylene?

One way of testing for tetrachloroethylene exposure is to measure the amount of the chemical in the breath, much the same way breath-alcohol measurements are used to determine the amount of alcohol in the blood.

Because it is stored in the body's fat and slowly released into the bloodstream, tetrachloroethylene can be detected in the breath for weeks following a heavy exposure.

Tetrachloroethylene and trichloroacetic acid (TCA), a breakdown product of tetrachloroethylene, can be detected in the blood. These tests are relatively simple to perform. These tests aren't available at most doctors' offices, but can be performed at special laboratories that have the right equipment.

Because exposure to other chemicals can produce the same breakdown products in the urine and blood, the tests for breakdown products cannot determine if you have been exposed to tetrachloroethylene or the other chemicals.

Has the federal government made recommendations to protect human health?

The EPA maximum contaminant level for the amount of tetrachloroethylene that can be in drinking water is 0.005 milligrams tetrachloroethylene per liter of water (0.005 mg/L).

The Occupational Safety and Health Administration (OSHA) has set a limit of 100 ppm for an 8-hour workday over a 40-hour workweek.

The National Institute for Occupational Safety and Health (NIOSH) recommends that tetrachloroethylene be handled as a potential carcinogen and recommends that levels in workplace air should be as low as possible.

Glossary

Carcinogen: A substance with the ability to cause cancer.

CAS: Chemical Abstracts Service.

Milligram (mg): One thousandth of a gram.

Nonflammable: Will not burn.

References

This ToxFAQs information is taken from the 1997 Toxicological Profile for Tetrachloroethylene (update) produced by the Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone:1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

TRICHLOROETHYLENE

CAS # 79-01-6

Division of Toxicology ToxFAQs™ **July 2003**

This fact sheet answers the most frequently asked health questions (FAQs) about trichloroethylene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Trichloroethylene is a colorless liquid which is used as a solvent for cleaning metal parts. Drinking or breathing high levels of trichloroethylene may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma, and possibly death. Trichloroethylene has been found in at least 852 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is trichloroethylene?

Trichloroethylene (TCE) is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers.

Trichloroethylene is not thought to occur naturally in the environment. However, it has been found in underground water sources and many surface waters as a result of the manufacture, use, and disposal of the chemical.

What happens to trichloroethylene when it enters the environment?

- Trichloroethylene dissolves a little in water, but it can remain in ground water for a long time.
- Trichloroethylene quickly evaporates from surface water, so it is commonly found as a vapor in the air.
- Trichloroethylene evaporates less easily from the soil than from surface water. It may stick to particles and remain for a long time.
- Trichloroethylene may stick to particles in water, which will cause it to eventually settle to the bottom sediment.
- Trichloroethylene does not build up significantly in plants and animals.

How might I be exposed to trichloroethylene?

- Breathing air in and around the home which has been contaminated with trichloroethylene vapors from shower water or household products such as spot removers and typewriter correction fluid.
- Drinking, swimming, or showering in water that has been contaminated with trichloroethylene.
- Contact with soil contaminated with trichloroethylene, such as near a hazardous waste site.
- Contact with the skin or breathing contaminated air while manufacturing trichloroethylene or using it at work to wash paint or grease from skin or equipment.

How can trichloroethylene affect my health?

Breathing small amounts may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating.

Breathing large amounts of trichloroethylene may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage.

ToxFAQs™ Internet address is http://www.atsdr.cdc.gov/toxfaq.html

Drinking large amounts of trichloroethylene may cause nausea, liver damage, unconsciousness, impaired heart function, or death.

Drinking small amounts of trichloroethylene for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear.

Skin contact with trichloroethylene for short periods may cause skin rashes.

How likely is trichloroethylene to cause cancer?

Some studies with mice and rats have suggested that high levels of trichloroethylene may cause liver, kidney, or lung cancer. Some studies of people exposed over long periods to high levels of trichloroethylene in drinking water or in workplace air have found evidence of increased cancer. Although, there are some concerns about the studies of people who were exposed to trichloroethylene, some of the effects found in people were similar to effects in animals.

In its 9th Report on Carcinogens, the National Toxicology Program (NTP) determined that trichloroethylene is "reasonably anticipated to be a human carcinogen." The International Agency for Research on Cancer (IARC) has determined that trichloroethylene is "probably carcinogenic to humans."

Is there a medical test to show whether I've been exposed to trichloroethylene?

If you have recently been exposed to trichloroethylene, it can be detected in your breath, blood, or urine. The breath test, if it is performed soon after exposure, can tell if you have been exposed to even a small amount of trichloroethylene.

Exposure to larger amounts is assessed by blood and urine tests, which can detect trichloroethylene and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products, so their detection is not absolute proof of exposure to trichloroethylene. This test isn't available at most doctors' offices, but can be done at special laboratories that have the right equipment.

Has the federal government made recommendations to protect human health?

The EPA has set a maximum contaminant level for trichloroethylene in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water.

The EPA has also developed regulations for the handling and disposal of trichloroethylene.

The Occupational Safety and Health Administration (OSHA) has set an exposure limit of 100 parts of trichloroethylene per million parts of air (100 ppm) for an 8-hour workday, 40-hour workweek.

Glossary

Carcinogenicity: The ability of a substance to cause cancer.
CAS: Chemical Abstracts Service.
Evaporate: To change into a vapor or gas.
Milligram (mg): One thousandth of a gram.
Nonflammable: Will not burn.
ppm: Parts per million.
Sediment: Mud and debris that have settled to the bottom of a body of water.
Solvent: A chemical that dissolves other substances.

References

This ToxFAQs information is taken from the 1997 Toxicological Profile for Trichloroethylene (update) produced by the Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs™ Internet address is http://www.atsdr.cdc.gov/toxfaq.html . ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

VINYL CHLORIDE

CAS # 75-01-4

Division of Toxicology and Environmental Medicine ToxFAQs™ **July 2006**

This fact sheet answers the most frequently asked health questions (FAQs) about vinyl chloride. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It is important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to vinyl chloride occurs mainly in the workplace. Breathing high levels of vinyl chloride for short periods of time can cause dizziness, sleepiness, unconsciousness, and at extremely high levels can cause death. Breathing vinyl chloride for long periods of time can result in permanent liver damage, immune reactions, nerve damage, and liver cancer. This substance has been found in at least 616 of the 1,662 National Priority List sites identified by the Environmental Protection Agency (EPA).

What is vinyl chloride?

Vinyl chloride is a colorless gas. It burns easily and it is not stable at high temperatures. It has a mild, sweet odor. It is a manufactured substance that does not occur naturally. It can be formed when other substances such as trichloroethane, trichloroethylene, and tetrachloroethylene are broken down. Vinyl chloride is used to make polyvinyl chloride (PVC). PVC is used to make a variety of plastic products, including pipes, wire and cable coatings, and packaging materials.

Vinyl chloride is also known as chloroethene, chloroethylene, and ethylene monochloride.

What happens to vinyl chloride when it enters the environment?

❑ Liquid vinyl chloride evaporates easily. Vinyl chloride in water or soil evaporates rapidly if it is near the surface.
❑ Vinyl chloride in the air breaks down in a few days to other substances, some of which can be harmful.
❑ Small amounts of vinyl chloride can dissolve in water.
❑ Vinyl chloride is unlikely to build up in plants or animals that you might eat.

How might I be exposed to vinyl chloride?

❑ Breathing vinyl chloride that has been released from plastics industries, hazardous waste sites, and landfills.
❑ Breathing vinyl chloride in air or during contact with your skin or eyes in the workplace.
❑ Drinking water from contaminated wells.

How can vinyl chloride affect my health?

Breathing high levels of vinyl chloride can cause you to feel dizzy or sleepy. Breathing very high levels can cause you to pass out, and breathing extremely high levels can cause death.

Some people who have breathed vinyl chloride for several years have changes in the structure of their livers. People are more likely to develop these changes if they breathe high levels of vinyl chloride. Some people who work with vinyl chloride have nerve damage and develop immune reactions. The lowest levels that produce liver changes, nerve damage, and immune reaction in people are not known. Some workers exposed to very high levels of vinyl chloride have problems with the blood flow in their hands. Their fingers turn white and hurt when they go into the cold.

The effects of drinking high levels of vinyl chloride are unknown. If you spill vinyl chloride on your skin, it will cause numbness, redness, and blisters.

Animal studies have shown that long-term exposure to vinyl chloride can damage the sperm and testes.

How likely is vinyl chloride to cause cancer?

The U.S. Department of Health and Human Services has determined that vinyl chloride is a known carcinogen. Studies in workers who have breathed vinyl chloride over many years showed an increased risk of liver, brain, lung cancer, and some cancers of the blood have also been observed in workers.

How can vinyl chloride affect children?

It has not been proven that vinyl chloride causes birth defects in humans, but studies in animals suggest that vinyl chloride might affect growth and development. Animal studies also suggest that infants and young children might be more susceptible than adults to vinyl chloride-induced cancer.

How can families reduce the risk of exposure to vinyl chloride?

Tobacco smoke contains low levels of vinyl chloride, so limiting your family's exposure to cigarette or cigar smoke may help reduce their exposure to vinyl chloride.

Is there a medical test to show whether I've been exposed to vinyl chloride?

The results of several tests can sometimes show if you have been exposed to vinyl chloride. Vinyl chloride can be measured in your breath, but the test must be done shortly after exposure. This is not helpful for measuring very low levels of vinyl chloride.

The amount of the major breakdown product of vinyl chloride, thiodiglycolic acid, in the urine may give some information about exposure. However, this test must be done shortly after exposure and does not reliably indicate the level of exposure.

Has the federal government made recommendations to protect human health?

Vinyl chloride is regulated in drinking water, food, and air. The EPA requires that the amount of vinyl chloride in drinking water not exceed 0.002 milligrams per liter (mg/L) of water.

The Occupational Safety and Health Administration (OSHA) has set a limit of 1 part vinyl chloride per 1 million parts of air (1 ppm) in the workplace.

The Food and Drug Administration (FDA) regulates the vinyl chloride content of various plastics. These include plastics that carry liquids and plastics that contact food. The limits for vinyl chloride content vary depending on the nature of the plastic and its use.

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. Toxicological Profile for Vinyl Chloride (Update). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology and Environmental Medicine, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

APPENDIX B

Worker Acknowledgement Forms

WORKER ACKNOWLEDGEMENT

RISK MITIGATION PLAN

I HAVE READ AND FULLY UNDERSTAND THIS RISK MITIGATION PLAN AND AGREE TO COMPLY WITH ITS CONTENTS DURING THE COMPLETION OF THE TASKS OF THIS PROJECT.

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